Assessing the Economy-wide Impacts of Natural Disasters: The Economic Impact of the 2009 Fiji Floods

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ABSTRACT

The Pacific is recognised as one of the most disaster prone regions in the world. As such, it is important to accurately estimate the economic losses associated with these natural disasters. This research estimates the higher order economic costs to Fiji as a result of the 2009 floods. The paper uses damage estimates to re-calibrate the underlying structure of the Fiji economy and estimates total economic impacts of the flood as a result of economic losses attributed to the flood. This structural change results in larger losses than would otherwise have occurred as linkages among domestic industries are weakened. Further, rebuilding and reconstruction after the flood will involve more resources as the multiplier effects are smaller due to the need for relatively more imports.

Keywords: *flood; disaster; economic impact; Fiji; South Pacific; input-output modeling*

1. INTRODUCTION

Natural disasters create two types of economic effects: destruction of property including infrastructure (damages) and the disruption of production, income and spending in the economy (losses). There has been a relatively long history of policy makers desiring to know the economic impact of disasters, both man-made and natural, on different industry sectors and the economy as a whole. The economic modeling of such disaster impacts has increased since the 1990s (Okuyama, 2007). The quantification of these damages and losses is essential to determine individual and community vulnerability, to price the value of mitigation, to determine the appropriate level of disaster assistance, to improve recovery decisions, and to inform insurers of their potential liability (Rose, 2004). However, while it is easier to evaluate damages due to disasters – that is the repairing or replacement cost of the assets destroyed or damaged, it is more difficult to evaluate the economic ripple effects of such events. Both Rose (2004) and Cochrane (2004) outline some of the problems in estimating ripple effects for such disasters. These problems include double counting, post-disaster liabilities, ignoring non-market losses, the degree of resiliency of the disaster-affected economy and the appropriate methodology to with which to measure higher-order impacts / the economic ripple effect. Okuyama (2007) provides a comprehensive review of past, present and future issues for the economic modeling of disaster impacts.

Throughout the literature there have been inconsistencies with terminology related to the analysis of disasters. This paper will follow Rose (2004) and Okuyama (2007). *Hazard* refers to the occurrence of a physical event, while a *disaster* is the consequence of that event (Okuyama, 2007, p. 116). Rose (2004, p. 14) makes the important distinction between stocks and flows. *Stocks* refer to a quantity at a single point in time, whereas *flows* refer to the goods or services of stock over time. Infrastructure damage and destruction of property corresponds to a decrease in stock value and business interruption losses are a flow measure. Lastly, the term *higher-order effects* will be used to describe the indirect economic impacts of subsequent intra-industry and inter-industry demand for inputs as a result of the direct economic impacts. The term *higher-order effects* are used as there is confusion over the term "indirect effects". Higher-order effects are referred to 'indirect effects' in input-output analysis but elsewhere indirect effects have referred to business interruption as a result of the direct effects of property damage (Rose, 2004, p. 16).

The Pacific is recognised as one of the most hazard prone regions on the world. The most frequent natural disasters that affect the region include earthquakes, tsunamis, volcanic activity, landslides, cyclones, flooding and drought. The Pacific region is particularly susceptible to natural disasters which may be exacerbated with predicted future climate change. It has been estimated that from 1950 to 2004, there have been 204 reported disasters affecting over 3.4 million people in the Pacific, resulting in over 1,700 fatalities (World Bank, 2006). These disasters pose a serious challenge to long-term sustainable development in the region given the high cost these disasters impose on Pacific island economies (Woodruff & Holland, 2008).

The purpose of this paper is to evaluate the higher order economic impacts of the 2009 Fiji Floods in Fiji. It is important for policy makers to account for the total economic impact of the disaster, over and above the direct economic impacts. The direct economic impacts of the flood are sourced from three documents. Two of the sources were produced by the Secretariat of the Pacific Community's Division of The Pacific Islands Applied Geoscience Commission (SPC-SOPAC). SPC-SOPAC provides economic support to disaster risk management which includes (i) post disaster assessment (ii) facilitation on assessments (ii) analysis of macroeconomic statistics related to disaster risk management (e.g., investment in GDP related to risk). Holland (2009) estimates some of the direct economic impacts of the 2009 Fiji floods on Nadi town and Ambroz's (2009) estimates some of the direct impacts of the 2009 Fiji floods for the Ba area. The third study is the Government of Fiji's assessment of the national flood damage (Government of Fiji, 2009). The former two reports, written under the auspices of SPC-SOPAC, focus on the private sector for distinct geographical areas while the Government of Fiji report estimates the damage on predominantly public sector industries and infrastructure. The three reports will be used as the basis for an economy-wide simulation of the total effects of the 2009 Fiji floods on the economy of Fiji.

The outline of the paper is as follows: Section 2 provides an overview of some of the other research that has evaluated the economy-wide impacts of both natural and man-made disasters. Section 3 briefly describes the different methodologies used to model the higher-order effects, concluding that input-output modeling is the most appropriate methodology to measure these effects in this case, given the characteristics of Fiji's economy. Section 4 outlines the relevant data for SPC-SOPAC's *Economic costs of January 2009 Nadi flood* report, the *Economic costs of January 2009 Ba floods* report and the Government of Fiji's *Consolidated Report on Flash Floods 8-16 January 2009, Damages Sustained and Necessary Responses, Rehabilitation and Reconstruction*. These direct economic costs will be used to simulate estimates of the economy-wide economic costs. This section also describes the salient characteristics of the 2007 Fiji input-output table from which the baseline results are calibrated. Section 5 shows the main results of the model and Section 6 concludes with policy recommendations.

2. THE ECONOMIC IMPACT OF DISASTERS

Globally, more than 7,000 major disasters have been recorded since 1970. These have resulted in an estimated $US2 trillion in damage, killing at least 2.5 million people and having significant social effects (United Nations, 2008). Damage and loss estimation from disasters has been the subject of a significant amount of research. Okuyama and Sahin (2009) estimate the global aggregate of economic impact of major disasters from 1960 to 2007. They estimate the aggregate damages to be $US 742 billion, losses are $US 360 billion, with the total impacts being around $US 680 billion, in 2007 US dollars. Noy, (2009) looking at a cross-section of disasters throughout the world for the last one hundred years, finds that developing countries and smaller economies face relatively large output declines following a disaster of similar magnitude than do developed countries or larger economics. This, he argues, has to do with that fact that countries with higher literacy rates, better institutions, higher per capita income, higher degree of openness to trade and higher levels of government spending are better able to withstand a disaster shock and prevent further spill-overs into the macroeconomy. Hochrainer (2009) examines 225 large natural disaster events from 1960 to 2005. He finds that natural disasters on average lead to significant negative effects of GDP and while the negative effects may be small, they can become pronounced depending on the degree of direct capital stock losses. Disasters in small island economies, as found in the Pacific, have a higher cumulative impact and the disasters cause more damage, as a proportion of GDP, compared to larger economies (The International Bank for Reconstruction and Development & The World Bank, 2010).

Myles *et al.* (2007) evaluate the economic impact of hurricanes Katrina and Rita on the agribusiness industry and related sectors in Mississippi. The authors state the hurricanes, which struck the Mississippi Gulf Coast in August 2005, were the most destructive to ever hit the United States, causing economic damage in excess of $US 2 billion in agriculture alone. Hallegatte models the economic impact of Hurricane Katrina on the economy of Louisiana (Hallegatte, 2008; Hallegatte & Henriet, 2008). He estimates the direct economic losses to be $US 107 billion, with the total economic costs estimated to $US 149 billion. He argues the need to look beyond direct losses and argues that analysis of forward and backward linkages between industry sectors are essential for the assessment of disaster consequences. This analysis takes into account production capacities which are essential to estimating the positive effects of reconstruction.

Several studies have assessed the impacts of the Northridge earthquake in Los Angeles in 1994 (Boarnet, 1998; Gordon, Richardson, & Davis, 1998; Tierney, 1997). These studies estimate the higher-order effects as well as direct impacts of this earthquake. The higher-order impacts include a substantial share of business interruption due to off-site problems, disruptions in the transportation system that restricted the movement of goods and the inability of employees to return to work. These higher-order impacts are often significant and depend on sectors which suffer the largest direct losses and their degree of interconnectedness with the remainder of the economy. West and Lenze (1994) model the regional impact of disaster and recovery of Hurricane Andrew, with particular focus on the information requirements needed to make an accurate assessment of the economic costs. The Los Angeles blackouts in 2001 were the subject of another study, estimating the direct and higher-order costs of the power failure (Rose, Oladosu, & Liao, 2007). The economic impact of water service disruptions after an earthquake has also been estimated (Rose & Liao, 2005). Anderson *et al.* (2007) demonstrate their Inoperability Input-Output model to assess the financial and inoperability effects of the Northeast United States Blackout of 2003. The authors argue the model is appropriate for itemising the regional economic losses of the Blackout, for describing the economic impact and percentage of inoperability incurred from a large-scale electric power disruption and as a tool to help conduct cost-benefit-risk trade-off analysis. This Blackout was estimated to incur a $US 2.12 billion loss from the electric power failure and a further $US 4.41 billion from workforce disruptions.

The examples cited above highlight the fact that higher-order losses often outweigh direct damage and loss estimates and policy interventions can have profound impacts on higher-order economic costs. Many of these assessments have been conducted in developed countries. However, it is perhaps more important to assess the economic impacts of disasters on small or developing economies. This is because many of these economies rely on one or two agricultural exports for much of their national income. Further, the small size of Pacific island economies means that disasters are felt disproportionately high by Pacific communities. As noted by SPC-SOPAC (2009, p.2-3) "…Cyclone Heta which hit Niue in 2004 generated immediate losses that exceeded the 2003 value of GDP by over five times. The 2007 earthquake and accompanying tsunami that hit the Solomon Islands cost the country around $SI 700 million – or around 90 per cent of the 2006 recurrent Government budget. Given current fears that climate change will increase the frequency and, or severity of natural disasters, the potential exists that the value of these losses could increase over time." Additionally, the lack of insurance in small or developing economies contributes to prolonged business interruption. This highlights the importance of research in small or developing countries found in this paper.

More recently, Fiji has developed a post disaster needs assessment (PDNA), which was first implemented following Tropical Cyclone Evan, a Category 4 cyclone that hit Fiji on the 16th and 17th December 2012 (Government of Fiji, 2013). Tropical Cycle Evan was estimated to cause a total of $FJ 194.9 million in economic costs with damages (destruction or damage to physical assets) summing to $FJ 121.5 million and losses (economic flows) totaling $FJ 73.4 million. The PDNA also provided estimates of damages and losses by industry sector with the largest damages and losses for this disaster occurring in the Hotel & Restaurants sector, the Housing Sector and Agriculture. Importantly, the methodology presented in this assessment reports (i) damage, loss and macroeconomic impacts on the affected economy; (ii) impacts on livelihoods, incomes and human development; (iii) short, medium, and long term recovery and reconstruction needs; and (iv) measures for mainstreaming disaster risk reduction in post-disaster and reconstruction plans (Government of Fiji, 2013, p. 5). This assessment method of economic disaster is now the standard of the Government of Fiji and will be used to assess future impacts of disasters. The methodology has been developed in collaboration with the World Bank, the Global Facility for Disaster Reduction and Recovery, various UN agencies, the European Commission, SPC among other stakeholders and represents best practice in this type of assessment.

3. MEASUREMENT OF THE ECONOMIC IMPACT OF DISASTERS

Rose (2004) discusses three broad categories of damage and loss estimation using economy-wide methodologies, each with their own advantages and disadvantages. Traditionally, input-output (and social accounting matrix - SAM) modeling has been the most widely used tool to estimate economic loss. The input-output table is a useful tool to evaluate the higher-order effects of a disaster across the economy as it displays the supply and demand relationships and dependencies between different sectors. Other advantages include the efficient organisational framework for data collection and display and the transparency of the analysis. However, there are significant disadvantages with this type of modeling. The model is linear, does not incorporate economic agent behaviour, and does not include resource constraints or the possibility of input or import substitution possibilities. As noted by Okuyama and Shahn (2009), input-output and SAM approaches tend to produce the upper limits of impact estimates.

Okuyama *et al.* (2002) uses a Sequential Interindustry Model, which extends the standard input-output framework with a dynamic formulation, with production chronology. Santos and Haimes use an "inoperability input-output model" (2004) where the model takes into account the degree to which each sector is now inoperable compared to the pre-disaster level.

CGE modeling can be a more sophisticated and realistic approach that builds in input-output modeling. It retains many of the advantages if input-output modeling while overcomes many of the disadvantages. In addition to the multi-sector characteristics, the model also incorporates factors of production/ import substitution, economic agents' responses to prices changes, both factor and product markets and resource constraints (non-infinite supply elasticities). However, CGE models assume consumers (producers) follow the neoclassical assumptions of utility (profit) maximisation. Yet, Cochrane (2004) notes that relative price changes before and after events tend to be small and short-lived. This negates one of the perceived benefits of CGE modeling. Hence equilibrium is restored primarily through the existence of excess capacity, and supply constraints and the injection of domestic and foreign aid rather than by product substitution.

While input-output models are overly rigid and tend to exaggerate shocks on the economy, CGE models can be overly flexible and understate the shocks on an economy. Often, this is a result of the substitution elasticities chosen, hence it is prudent to undertake sensitivity analysis with respect to the values of the underlying elasticity parameters.

Econometric models, which statistically estimate simultaneous equations of the aggregate relationships of an economy, have been used sparingly to predict the impact of disasters across the economy. This is due to their expense, large data demands and the difficulty in distinguishing between direct and higher-order effects.

Given the above arguments, most notably the absence of significant changes in prices post-event, this research will utilise a modified input-output model, along the lines of Santos and Haimes (2004). This type of modeling offers the best potential to estimate the higher-order effects of the 2009 Nadi floods. In Fiji, this argument is further enhanced with the existence of the Prices and Incomes Board / Commerce Commission whose role it is to monitor (and if necessary regulate) prices of almost 150 different products. Hence, in this paper, a modified input-output model is then applied to estimate the macroeconomic impacts of the 2009 floods in Fiji. A description of the model used can be found in Section 4.

4. 2009 FIJI FLOODS AND THE FIJIAN ECONOMY

In January 2009, heavy rain resulting from a tropical depression caused severe flooding in the North, Central and Western Divisions of Fiji. Areas devastated by the flood included the towns of Nadi, Ba and Labasa. At the height of the floods on January 16th, 169 evacuation centres catered for 11,458 people (Government of Fiji, 2009). Nationwide, 11 fatalities occurred, including two deaths from flood related landslides. The Government of Fiji declared a 30 day state of natural disaster on January 11th, 2009. Table 1 shows the economic cost assessment made for the floods from three different sources. The SPC-SOPAC reports concentrated on sectors that were not covered by the Government of Fiji's flood damage assessments, that is, costs from the floods to households and businesses in town areas. The Government assessment covers the public sector and primary sector industries. The damage estimates for each report can be simulated independently and in combination.

TABLE 1: *Flood Damage Assessment by Source ($FJ'000)*

	Sector	Nationwide (1)	Nadi (2)	Ba (3)	Total (4)
1	Sugar	24,600.00			24,600.00
2	Other Crops	15,968.05			15,968.05
3	Dairy and Livestock	3,995.80			3,995.80
4	Manufacturing		18,050.00	17,479.70	35,529.70
5	Electricity & water	14,220.00			14,220.00
6	Construction	19,466.01			19,466.01
7	Retail & Wholesale Trade		59,783.33	22,997.62	82,780.95
8	Restaurants		7,805.77	8,995.56	16,801.33
9	Transport	29,751.30			29,751.30
10	Real Estate	3,000.00			3,000.00
11	Business Services		143,755.86	6,400.79	150,156.65
12	Health	515.00			515.00
13	Education	1,473.96			1,473.96
14	**Total Industry**	**112,990.12**	**229,394.96**	**55,873.68**	**398,258.75**
15	**Household Demand**	**N/A**	**14,526.74**	**30,520.60**	**45,047.33**

(1) Consolidated Report on Flash Floods 8-16 January 2009, Damages Sustained and Necessary Responses, Rehabilitation and Reconstruction.

(2) Economic costs of January 2009 Nadi floods report

(3) Economic costs of January 2009 Ba floods report

The underlying benchmark data used to model the economy comes from Kumar (2001). This original data set was constructed for the year 2002. The input output table was then put through a RAS procedure to update the matrix to 2007 with the target GDP by sector data published by Fiji's Bureau of Statistics. RAS is a widely used methodology to balance or update input output tables. It is used when new information on the matrix row and column sums becomes available. The input-output table has been aggregated into 17 sectors listed in Table 2. The table differentiates final demand into household consumption, exports, tourist expenditures, government consumption, government investment and private investment. The table also differentiates final payments into labour income, operating surplus, several different taxes (company taxes, production taxes, tariffs) and imports.

TABLE 2: *Sectoral Detail*

Sugar
Other Crops
Dairy and Livestock
Forestry, Fishing & Mining
Manufacturing
Electricity & water
Construction
Retail & Wholesale Trade
Hotels
Restaurants
Transport
Real Estate
Business Services
Health
Education
Other government services
Informal sector

5. THE MODEL

Input-output analysis assesses the effects of an exogenous change on the economy through the use of input-output multipliers. It is important to distinguish between an input-output table and input-output models. An input-output table is not a model in itself and can be used in other types of modeling, such as Social Accounting Matrix (SAM) modeling and CGE modeling.

Input Output analysis involves manipulating the national accounting identities to derive the direct requirements table and the total requirements table in order to arrive at the Leontief inverse matrix (see Miller & Blair 1985 for details). In vector notation, this can be expressed as:
$X = (I - A)^{-1} FD$ where X is the vector of industry total outputs; I is an Identity matrix; A is the technology matrix; and FD is a vector of total final demands. $(I - A)^{-1}$ is known by several terms—the total requirements matrix or the Leontief inverse matrix. where *I* is an Identity matrix.

The direct effect measures the initial effect attributable to the exogenous change, while the higher-order effects measure the subsequent intra-industry and inter-industry demand for inputs as a result of the initial change in output of the directly affected industry.

A number of authors (Myles, et al., 2007) describe the devastating damage to the economy caused by the natural disaster but then argue that the damages caused will not result in major changes to the overall structure of the economy, without any justification why they make this assumption. These authors then proceed to use the standard input-output model to estimate the economic impacts caused by the disaster (e.g. Myles et al., 2007).

The research in this paper recognises that the damage caused by natural disasters can fundamentally impact both the backward and forward linkages of different industries in the economy. Hence, the flood damage assessments estimated in Table 1 need to be taken into account to make an adjustment to the structure of the economy as a result of the flood. This level of inoperability needs to be taken into account so while there is a decrease in household demand, there is also a change in the underlying structure of the economy as the floods resulted in a depletion of the capital stock in the economy. The initial impact of the flood on the productivity of each sector can be seen in Table 3. The flood effectively wiped off 40% of the value of the Restaurant sector and 36% of the Business Services sector, while almost 24% was lost in the Sugar sector.

In terms of the impact of the floods on Fiji's tourism industry, the SPC-SOPAC reports did not report the estimates of the economic costs (damages and losses) on Denarau Island, hence the Hotel sector was not included in the analysis on high-order effects. Denarau Island "is a reclaimed area of land located 3 kilometres to the west of Nadi town that hosts international hotel resorts as well as shopping complexes, tourist activities and housing developments. Denarau Island was not flooded by river rise during the January 2009 floods, but some businesses were affected by high tides, leading to salt water flooding of premises and associated problems (damaged carpets, blocked pipes etc.). Further, a number of hotels suffered financially from the flood related tourist cancellations and from the island being cut off as a result of flooded roads" (Holland, 2009, p. 31).

Additionally, examining visitor arrivals to Fiji at the time of the flood, the analysis would be somewhat subjective in terms of attributing decreases in visitor arrivals as a result of the floods and those decreases as a result of the Global Financial Crisis. Further, there is anecdotal evidence to such that international tourists deferred rather than cancelled their trip to Fiji, hence the longer term impact of the flood on visitor arrivals may have been minimal.

TABLE 3: *Pre- and Post-Flood Damage on GDP by Sector ($FJ'000)*

GDP by Sector	Pre-Flood	Post-Flood	Damaged %
Sugar	103,730	79,130	23.7%
Other Crops	138,361	122,393	11.5%
Dairy Livestock	35,951	31,955	11.1%
Manufacturing	606,251	570,721	5.9%
Electricity & water	177,565	163,345	8.0%
Construction	212,229	192,763	9.2%
Retail & Wholesale Trade	510,095	427,314	16.2%
Restaurants	41,944	25,143	40.1%
Transport	697,121	667,370	4.3%
Real Estate	222,944	219,944	1.3%
Business Services	417,387	267,230	36.0%
Health	129,625	129,110	0.4%
Education	300,497	299,023	0.5%

The direct and higher-order impact of a change in final demand (ΔFD) can now be expressed as: $\Delta X^* = (I - A^*)^{-1} \Delta FD$ where ΔX^* is the total change in industry total outputs as a result of both the decreased household consumption and the modified structure of the economy; I is the Identity matrix; A* is a modified technology matrix that takes into account the damage caused by the flood in each sector; and ΔFD is the change in final household consumption (losses) as a result of the flood.

The estimated direct losses from the source reports are designated as changes in household consumption (ΔFD) as a result of the floods (Table 1, Row 15). These losses are applied to the input-output model described in Section 5. As the change in household consumption was not disaggregated by industry, a reasonable approach would be to allocate household consumption based on the industries' shares in total household expenditure in the input-output table. Type I output, value added and leakages multipliers have been calculated for both the pre-flood economy (A) and the post-flood economy (A^*). The results of this modeling are found in Section 6.

6. RESULTS

The direct impacts of the floods on household consumption is estimated to be $FJ 14.5 million for the Nadi area and $FJ 30.5 million for Ba for a total of $FJ 45.0 million. However, with Fiji being heavily reliant on imports and another proportion of household expenditure being taxed (excise duties, tariffs and value added tax); the net economic cost to the Fijian economy is significantly less than gross household consumption. The direct net loss to the domestic economy is estimated to be $FJ 19.4 million. Table 4 shows the total (direct and higher-order) economic costs of the 2009 Fiji floods using the modified (post-flood) input-output multipliers. The impacts of three different economic variables are shown. These figures, split by geographical region, employ the output multipliers, the value-added multiplier (this multiplier calculates the direct and higher-order contribution to income, both labour and capital) and the leakages multiplier (this multiplier calculates the direct and higher-order contribution to leakages, both taxes and imports).

TABLE 4: *Total (Direct & Higher Order) Losses in the 2009 Fiji Floods ($FJ million)*

	Nadi	Ba	Total
Output	$6.96	$14.63	$21.59
Value Added	$4.89	$10.28	$15.17
Leakages	$1.36	$2.86	$4.22

The loss of output in Nadi, including both direct and higher-order effects, is $6.96 million while for Ba it is $14.63 million for a total of $21.59 million. In terms of the loss of income, the flood resulted in a $15.17 million loss of labour and capital income. In addition to the direct impact of a $25.6 million decrease in imports and taxes as a result of foregone consumption, a further $4.22 million in leakages has been lost in higher order effects. In sum, the direct domestic loss to output is $FJ 19.4 million, while the direct and indirect loss is calculated to $FJ 21.59 million;

a loss of a further 10%.

Using the methodology described above, the post-flood economy was assumed to be substantially different to the pre-flood economy. The flood was assumed to modify the inter-industry transactions as well as fundamentally change the final payment sectors. The modification of the structure of the economy is made using the flood damage assessments shown in Column 4, Rows 1-13 of Table 1. Assuming the economy fundamentally changed post-disaster, different multipliers apply to the post-disaster economy. Table 5 presents a comparison of the direct and indirect impacts for output, value added and leakages using these different multipliers. The losses are larger in the scenario where the economy is assumed to have structurally changed. The loss in output is larger ($21.6 million compared to $21.0 million) and loss in leakages is larger as well, but the loss of income (value added) is smaller in the post-flood economy.

TABLE 5: *Difference in Losses due to Restructured Economy ($FJ million)*

	Pre-Flood Economy	Post-Flood Economy	Difference
Output	$20.95	$21.59	$0.63
Value Added	$17.98	$15.17	-$2.81
Leakages	$1.43	$4.22	$2.79

To determine the reason for the differences in impacts, it is useful to compare the pre-flood and post-flood multipliers as well as the pre- and post-flood backward and forward linkages. Backward linkages measure the relative importance of each industry sector as a purchaser to all other sectors in the economy. In contrast, forward linkages measure the relative importance of each sector as a supplier to all other sectors in the economy. Linkages show the degree of interconnectedness of different industry sectors throughout the economy.

TABLE 6: *Comparison of Pre-Flood & Post-Flood Linkages and Multipliers*

	Backward Linkages			Forward Linkages			Value Added Multipliers			Leakages Multipliers		
	PRE	POST	Diff	PRE	POST	Diff	PRE	POST	Diff	PRE	POST	Diff
	A	B	C	D	E	F	G	H	I	J	K	L
Sugar	1.07	1.02	-0.05	1.19	1.14	-0.05	0.95	0.91	-0.03	0.05	0.08	0.03
Other Crops	1.01	0.96	-0.06	0.95	0.93	-0.02	0.96	0.91	-0.05	0.04	0.09	0.05
Dairy Livestock	1.04	1.00	-0.03	0.97	0.96	-0.01	0.89	0.64	-0.24	0.11	0.35	0.24
Forestry Fishing Mining	1.01	0.96	-0.06	1.00	1.00	0.01	0.92	0.92	0.00	0.08	0.08	0.00
Manufacturing	1.25	1.18	-0.07	0.99	0.93	-0.06	0.89	0.64	-0.25	0.11	0.36	0.25
Elect & water	1.01	0.97	-0.05	1.02	1.10	0.08	0.92	0.93	0.01	0.08	0.07	-0.01
Construction	1.05	0.98	-0.06	0.96	0.93	-0.02	0.92	0.56	-0.37	0.08	0.44	0.37
Retail & Wholesale Trade	1.05	1.03	-0.02	0.97	0.93	-0.04	0.93	0.90	-0.04	0.07	0.10	0.03
Hotels	1.06	1.01	-0.04	0.95	0.94	-0.02	0.92	0.72	-0.20	0.08	0.28	0.20
Restaurants	1.08	1.00	-0.08	0.95	0.93	-0.02	0.89	0.51	-0.38	0.11	0.49	0.38
Transport	1.03	0.97	-0.06	0.96	0.96	0.00	0.87	0.51	-0.35	0.13	0.48	0.35
Real Estate	1.07	1.07	0.00	0.99	1.02	0.04	0.90	0.72	-0.17	0.10	0.27	0.17
Services	1.03	0.99	-0.04	1.27	1.41	0.14	0.93	0.82	-0.11	0.07	0.18	0.11
Health	1.01	0.97	-0.04	0.96	0.99	0.03	0.95	0.79	-0.16	0.05	0.21	0.16
Education	1.01	0.97	-0.04	0.96	0.95	-0.01	0.99	0.94	-0.05	0.01	0.06	0.05
Other gov services	1.01	0.96	-0.05	0.95	0.93	-0.02	0.99	0.89	-0.10	0.01	0.11	0.10
Informal sector	1.02	0.97	-0.05	0.96	0.93	-0.02	0.98	0.82	-0.16	0.02	0.18	0.16

As can be seen in Table 6, across all sectors, backward linkages are smaller in the post-flood economy than the pre-flood economy (Column C). This means that the degree to which one sector is a supplier to other sectors is weaker after the flood. However, in the case of forward linkages, the case is not so clear. Twelve out of the 17 sectors have weaker forward linkages in the post-flood economy (Column F). Most notably the Business Services sector has stronger forward linkages after the flood. In general, the value added multipliers are larger in the pre-flood scenario than the post-flood economy while, on average, the leakages multipliers are larger in the post-flood scenario. This implies that, all else being equal, losses as a result of natural disasters will result in a larger increase in imports and a lower increase in domestic income after the flood, as a result of more damage. These values would be more pronounced if data on private losses (as per the SPC-SOPAC reports) were available for the entire country.

CONCLUSIONS

The direct economic costs to businesses (damages) in Nadi and Ba as reported by SPC-SOPAC were $FJ 229.4 million and $FJ 55.9 million respectively while the direct economic costs to households (losses) were estimated to be $FJ 14.5 million for Nadi and $FJ 30.5 million for Ba. For other areas of Fiji, total industry costs (damages) were estimated to $FJ 113.0 million (Government of Fiji 2009). The higher-order effects on economic output to Fiji estimated in this study ($FJ 7.0 million for Nadi and $14.6 million for Ba) were found to be lower than the direct losses due to the high propensity of imports consumed by Nadi and Ba households. Economic losses decrease both spending and invest on both domestic goods and services and imported products.

This paper calculates the higher order effects of the 2009 Fiji floods. The paper uses damage estimates to re-calibrate the underlying structure of the Fiji economy and estimates total economic impacts of the flood as a result of economic losses attributed to the flood. The paper assumes natural disasters can fundamentally change the underlying structure of the economy and inter-industry relationships between sectors. With the flood wiping out part of the supply capacity of certain sectors, the linkages between sectors have weakened. This results in larger losses than would otherwise be the case as a result of decreases in household consumption. The floods also resulted in larger leakage multipliers and smaller value added multipliers. This means that any stimulus package involving increases in government investment, foreign aid or private sector investment would have less impact than would otherwise be the case. This type of study, examining the higher-order effects of a natural disaster, complements and extends studies which estimate direct economic costs.

In terms of policy implications, the sector with the largest backward and forward linkages and multipliers are the sectors that have the potential to accelerate economic growth in the economy. Re-establishing the supply chain of these sectors will best contribute to a faster post-disaster recovery. The manufacturing sector and Restaurant sector have the largest pre-disaster backward linkages and the Sugar industry and Business Services have the largest forward linkages. These are the sector that should be prioritised for recovery.

At the time of the 2009 flood, there was little importance given to systematic assessment of the macroeconomic assessments of disasters in Fiji by the Government of Fiji. However, since the PDNA approach used in assessing the economic costs of Tropical Cyclone Evan in December 2012, there has been a significant and unified approach to the economic assessment of disasters as well as costing the recovery and reconstruction effort. The PDNA approach quantifies damage and loss assessment by sector. This approach also estimates pre- and post-disaster estimates of several macroeconomic indicators such as GDP, import and exports, the balance of payments and the government budget. Hence, other Pacific Island countries can follow Fiji's lead in undertaking this type of analysis using a standardised methodology. This will enable more accurate comparisons to be made over time, space and governance structures. Nevertheless, the PDNA methodology seems to stop short of calculating higher-order economic costs. As such, it is recommended that modeling found in this research can complement the systematic and methodological PDNA assessments and could be conducted for all future disaster analyses, especially in the Pacific, where possible.

Estimating these higher-order impacts quantifies the total economic impact of such disasters and provides policy makers with a more complete picture of the losses associated with disasters. However, data scarcity is an issue with many South Pacific central statistical offices either not producing or not distributing an input output table with which this type of modeling can be conducted. More publically available and more accurate and timely data should be a priority for these economies. Many of the deficiencies noted in the other literature also exist here. This type of analysis ignores non-market losses and there is little agreement on how indirect loss models can be verified.

There are further areas where this research could be extended. One option would be to look at the distributional impacts of the floods. This would involve modifying the existing input-output table into a social accounting matrix to trace income and consumption flows by different household types and income levels. This would enable the analysis to answer questions such as: to what extent does this disaster impact the poor compared to the rich. Another option would be to model the reconstruction stimulus and /or aid transfers to the economy and compare it with damage and loss estimates.

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